

5 A plate heat exchanger

THE BACKGROUND OF THE INVENTION AND PRIOR ART

10 The present invention refers generally to a plate heat exchanger, in particular a plate heat exchanger in the form of an evaporator, i. e. a plate heat exchanger designed for evaporation of a cooling agent in a cooling agent circuit for various applications, such as air conditioning, cooling systems, heat pump systems, etc.

15 The present invention refers especially to a plate heat exchanger, including a plate package, which includes a number of first heat exchanger plates and a number of second heat exchanger plates, which are permanently joined to each other and
20 arranged beside each other in such a way that a first plate interspace is formed between each pair of adjacent first heat exchanger plates and second heat exchanger plates and a second plate interspace between each pair of adjacent second heat exchanger plates and first heat exchanger plates, wherein the first
25 plate interspaces and the second plate interspaces are separated from each other and provided beside each other in an alternating order in the plate package, wherein substantially each heat exchanger plate has at least a first porthole and a second porthole, wherein the first portholes form a first inlet channel to
30 the first plate interspaces and the second portholes form a first outlet channel from the first plate interspaces and wherein the plate package includes a separate space for each of said first plate interspaces, which space is closed to the second plate interspaces.

The cooling agent supplied to the inlet channel of such a plate heat exchanger for evaporation of the cooling agent is usually present both in a gaseous state and a liquid state. It is then difficult to provide an optimum distribution of the cooling agent to

5 the different plate interspaces in the evaporator in such a way that an equal quantity of cooling agent is supplied and flows through each plate interspace. It is known that this problem of the distribution of the cooling agent at least partly can be solved by providing a throttling of the cooling agent at each plate interspace.

10 In such a way a pressure drop of the cooling agent is obtained when it enters the respective plate interspace.

SE-C-502 984 discloses a plate heat exchanger of the kind initially defined having an inlet channel for a cooling agent. The

15 inlet channel is through compression-moulding of the heat exchanger plates completely closed to the second plate interspaces for the fluid to be cooled and has a number of small openings extending to each of the first plate interspaces. These openings form throttlings, which provide a certain pressure drop

20 of the cooling agent at the entrance into the respective plate interspace. The small openings may be designed as a hole through the sheet of each heat exchanger plate or as a thin channel provided through the compression-moulding.

25 US-A-5,971,065 discloses a similar plate heat exchanger having a number of small openings between the inlet channel for the cooling agent and the respective plate interspace. The plate heat exchanger according to US-A-5,971,065 differs from the solution proposed in the above-mentioned SE-C-502 984 in that

30 a common space for the cooling agent has been created through the compression-moulding between the inlet channel and the respective plate interspace for the cooling agent. This common space extends through substantially the whole plate package in parallel to the inlet channel. A plurality of small openings extend

35 between the inlet channel and the common space, and at least

one small hole extends between the common space and each of the plate interspaces for the cooling agent.

EP-B-1 203 193 disclosed another plate heat exchanger including a package with heat exchanger plates, which together with sealing means defines first plate interspaces and second plate interspaces. The inlet channel is partly closed to the first plate interspaces by means of loose gaskets. The inlet channel communicates according to an embodiment disclosed with the first plate interspaces by means of small pipes extending through the respective gasket and forming a small opening for throttling of the cooling agent flow.

With the solutions proposed in these documents, it can be difficult to obtain a sufficient pressure drop for achieving an acceptable distribution of the cooling agent in the different first plate interspaces. In particular, a large pressure drop is required for cooling agents having a relatively high density in a gaseous state, for instance the cooling agent R410a. Another problem with the solutions proposed in these documents is that they can be difficult to apply to plate heat exchangers having small dimensions. In such small plate heat exchangers, there is not sufficient space around the inlet channel for the proposed solutions. In particular, the small channels provided through compression-moulding can tend to be clogged when the heat exchanger plates having a small mould depth of the thin channels are brazed to a plate package.

SUMMARY OF THE INVENTION

The object of the present invention is to provide an improved plate heat exchanger remedying the problems mentioned above. Especially it is aimed at a plate heat exchanger, which creates a sufficient pressure drop in a cooling agent at the entrance into the respective plate interspace.

A further object of the invention is to provide a plate heat exchanger, which may be manufactured with small dimensions.

This object is achieved by the plate heat exchanger initially defined, which is characterised in that said separate space communicates with the first inlet channel via an inlet nozzle, which forms a throttling with significantly reduced flow area, and with the respective first plate interspace via an outlet nozzle, which forms a throttling with significantly reduced flow area.

In its general form, the present invention thus defines two throttlings provided in series with each other and a separate space lying between the throttlings for each plate interspace. With such a flow path, an efficient total throttling may be achieved when a cooling agent enters the respective plate interspace in such a way that a sufficient pressure drop is ensured for achieving a uniform distribution of the cooling agent in all of the first plate interspaces. The separate spaces may in principal be provided in a substantially arbitrary position in the plate package. According to an advantageous embodiment of the invention, said separate space is, however, provided in the proximity of the inlet channel. Especially, these separate spaces may be provided around the inlet channel.

According to a further embodiment of the invention, said separate space has been produced through compression-moulding of the heat exchanger plates. In such a way, the plate package and the plate heat exchanger according to the invention may be manufactured in an easy and inexpensive manner.

According to a further embodiment of the invention, at least one of said nozzles is formed by a respective hole, which extends through each of said heat exchanger plates. Such a nozzle in the form of a hole may be provided in an easy manner from a manufacturing point of view. Such a hole also has the advantage that it may form an effective throttling and at the same time en-

sure that the nozzle remains open, for instance in connection with brazing of the plate package.

According to a further embodiment of the invention, the inlet nozzle is formed by a respective hole, which extends through each of said second heat exchanger plates. Furthermore, also the outlet nozzle may advantageously be formed by a respective hole, which extends through each of said second heat exchanger plates. Thereby, said separate space may be provided between a respective pair of adjacent second heat exchanger plates and first heat exchanger plates, i.e. said separate spaces are provided between the same pair of heat exchanger plates as the second plate interspaces.

According to a further embodiment of the invention, each of said heat exchanger plates includes a central extension plane, an upper plate plane on one side of the central extension plane and a lower plate plane on the other side of the central extension plane. Each of said second heat exchanger plates may then include an upper surface area, which extends around said first porthole and which delimits said separate space, wherein the upper surface area is located at the level of the upper plate plane.

According to a further embodiment of the invention, the hole of the outlet nozzle extends through the upper surface area. The plate heat exchanger may then advantageously include an end plate, which is provided adjacent to one of said second heat exchanger plates in such a way that it closes the hole of the outlet nozzle of this second heat exchanger plate. This embodiment is especially advantageous since the outermost of said separate spaces will be sealed to the environment by means of a single, substantially plane end plate abutting said second heat exchanger plate.

According to a further embodiment of the invention, each of said second heat exchanger plates includes a lower surface area, which extends around said first porthole between the first port-hole and the upper surface area, wherein the lower surface area 5 is located at the level of the second lower plate plane. The hole of the inlet nozzle may then extend through the lower surface area.

According to a further embodiment of the invention each of said 10 first heat exchanger plates includes a lower surface area, which extends around said first porthole and which delimits said separate space, wherein the lower surface area is located at the level of the lower plate plane. The upper surface area of said second heat exchanger plates may then be located partly opposite 15 to the lower surface area of said first heat exchanger plates for forming said separate space between these areas. In order to create a passage into said separate space, the inlet nozzle may be located opposite to the lower surface area of said first heat exchanger plates. In order to create a passage from said 20 separate space into said first plate interspace, the outlet nozzle may, with regard to the extension plane, be displaced in relation to the lower surface area of said first heat exchanger plates.

According to a further embodiment of the invention, each of said 25 first heat exchanger plates includes an upper surface area, which extends around said first porthole between the first port-hole and the lower surface area, wherein the upper surface area is located at the level of the upper plate plane. Furthermore, the lower surface area of said second heat exchanger plates may be 30 located partly opposite to the upper surface area of said first heat exchanger plates, wherein these two surface areas partly abut each other in the plate package.

According to a further embodiment of the invention, said first 35 plate interspaces form first passages for a cooling agent and said second plate interspaces form second passages for a fluid,

which is adapted to be cooled by the cooling agent. The plate heat exchanger may then advantageously be adapted to operate as an evaporator.

5 According to a further embodiment of the invention, substantially each exchanger plate has at least a third porthole and a fourth porthole, which extend through the plate package, wherein the third portholes form a second inlet channel to the second plate interspaces and the fourth portholes form a second outlet channel from the second plate interspaces.

According to a further embodiment of the invention, said heat exchanger plates in the plate package are connected to each other through brazing.

15 According to a further embodiment of the invention, said separate space is delimited by means of at least one ring, which extends around the inlet channel. Each of said rings may then be provided in a ring groove in the adjacent heat exchanger plate.

20 **BRIEF DESCRIPTION OF THE DRAWINGS**

25 The present invention is now to be explained more closely by means of a description of various embodiments disclosed by way of example, and with reference to the drawings attached hereto.

30 Fig. 1 discloses schematically a side view of a plate heat exchanger according to an embodiment of the invention.

Fig. 2 discloses schematically a front view of the plate heat exchanger in Fig. 1.

Fig. 3 discloses schematically a sectional view along the line III-III in Fig. 2.

35 Fig. 4 discloses schematically a side view of a first heat exchanger plate of the plate heat exchanger in Fig. 1.

Fig. 5 discloses schematically a side view of a second heat exchanger plate of the plate heat exchanger in Fig. 1.

Fig. 6 discloses schematically a view from above of the first heat exchanger plate in Fig. 4.

5 Fig. 7 discloses schematically a view from above of the second heat exchanger plate in Fig 5.

Fig. 8 discloses schematically a sectional view similar to the one in Fig. 3 of another embodiment of the invention.

10

DETAILED DESCRIPTION OF VARIOUS EMBODIMENTS OF THE INVENTION

Figs. 1 to 3 disclose a possible embodiment of the plate heat exchanger according to the invention. The plate heat exchanger includes a plate package P, which is formed by a number of compression-moulded heat exchanger plates A, B, which are provided beside each other. The heat exchanger plates include in the embodiment disclosed two different plates, which in the following are called the first heat exchanger plates A, see Figs. 3, 4 and 6, and the second heat exchanger plate B, see Figs. 3, 5 and 7. As is clear the plate package P includes substantially the same number of first heat exchanger plates A and second heat exchanger plates B.

25

As is clear from Fig. 3, the heat exchanger plates A, B are provided beside each other in such a way that a first plate interspace 1 is formed between each pair of adjacent first heat exchanger plates A and second heat exchanger plates B, and a second plate interspace 2 between each pair of adjacent second heat exchanger plates B and first heat exchanger plates A. Every second plate interspace thus forms a respective first plate interspace 1 and the remaining plate interspaces form a respective second plate interspace 2, i.e. the first and second plate interspaces 1 and 2 are provided in an alternating order in the plate package P. Furthermore, the first and second plate inter-

spaces 1 and 2 are substantially completely separated from each other.

5 The plate heat exchanger according to the invention may advantageously be adapted to operate as an evaporator in a cooling agent circuit, not disclosed. In such an evaporator application, the first plate interspaces 1 may form first passages for a cooling agent whereas the second plate interspaces 2 form second passages for a fluid, which is adapted to cooled by the 10 cooling agent.

15 The plate package P also includes an upper sealing plate 3 and a lower sealing plate 4, which are provided on a respective side of the plate package P and form the end plates of the plate package. In the embodiment disclosed, the heat exchanger plates A, B and the sealing plates 3, 4 are permanently connected to each other. Such a permanent connection may advantageously be performed through brazing. Other possible 20 connection techniques include welding and gluing. However, it is also possible to apply the invention to plate heat exchangers where the plate package P is kept together by tie-bolts extending through the heat exchanger plates A, B and the sealing plates 3, 4.

25 As appears from especially Figs. 2, 6 and 7, substantially each heat exchanger plate A, B has four portholes 5, namely a first porthole 5, a second porthole 5, a third porthole 5 and a fourth porthole 5. The first portholes 5 form a first inlet channel 6 to the first plate interspaces 1, which extends through substantially 30 the whole plate package P, i. e. all plates A, B and 3 except for the sealing plate 4. The second portholes 5 form a first outlet channel 7 from the first plate interspaces 1, which also extends through substantially the whole plate package P, i.e. all plates A, B and 3 except for the sealing plate 4. The third portholes 5 35 form a second inlet channel 8 to the second plate interspaces 2, and the fourth portholes 5 form a second outlet channel 9 from

the second plate interspaces 2. Also these two channels 8 and 9 extend through substantially the whole plate package P, i.e. all plates A, B and 3 except for the sealing plate 4. The four port-holes 5 are provided in the proximity of a respective corner of

5 the substantially rectangular heat exchanger plates A, B. In a central area of each heat exchanger plate A, B there is an active heat transfer area 10, which is provided with a corrugation of ridges and valleys in a manner known per se. In the embodiment disclosed the corrugations extend in a herringbone-like pattern,

10 wherein the corrugations of the first heat exchanger plates A point in a direction and the corrugations of the second heat exchanger plates B point in the opposite direction. The heat transfer area 10 may of course have other kinds of patterns.

15 The heat exchanger plates A and B are compression-moulded in such a way that a separate space 11 is formed around the first inlet channel 6. Each separate space 11 is substantially completely closed to the second plate interspaces 2. As is clear from Fig. 3, each separate space 11 is provided between a respective

20 pair of adjacent second heat exchanger plates B and first heat exchanger plates A, i.e. the separate spaces 11 are provided between the same pair of the heat exchanger plates B and A as the second plate interspaces 2.

25 It is to be noted here that the invention also may be performed by means of non compression-moulded, i.e. substantially plane heat exchanger plates. In such a variant, the separate spaces 11 may be produced by means of rings 31, 32 located between the heat exchanger plates A, B, see Fig 8. For instance there

30 may be such an inner ring 31 immediately outside the inlet channel and a second outer ring 32 somewhat outside the first inner ring, wherein the separate space 11 is located between the rings 31, 32. The invention also includes combinations of these solutions, i.e. the separate spaces 11 may be delimited by

35 a delimiting surface, provided through the compression-moulding, and by a ring. Embodiments having one or several

rings 31, 32 may also be combined with a compression-moulded central heat transfer area 10 with corrugations having a suitable pattern, see Fig. Furthermore, each heat exchanger plate A, B may be provided with one or two ring grooves for receiving one 5 or both rings 31 and 32, in such a way that each of said rings 31, 32 are provided in a ring groove in the adjacent heat exchanger plate A, B.

Each such separate space 11 communicates with the first inlet 10 channel 6 and with a respective one of the first plate interspaces 1. Each separate space 11 communicates with the first inlet channel 6 via an inlet nozzle forming a throttling having a significantly reduced flow area. Each separate space 11 communicates with a respective first plate interspace 1 via an outlet nozzle 15 forming a throttling with a significantly reduced flow area. The flow area of the two nozzles is thus significantly reduced in comparison with the flow area of the first inlet channel 6 and in comparison with the flow area of each of the first plate interspaces 1. In the embodiment disclosed, the inlet nozzle is formed by a hole 13 extending through each second heat exchanger plate B. The outlet nozzle is formed in a corresponding manner by a hole 14, extending through each second heat exchanger plate B. In the embodiment disclosed, the cooling agent is thus conveyed from the first inlet channel 6 through the holes 20 13 in the separate spaces 11 and from there through the holes 14 out into the first plate interspaces 1. Thanks to the fact that the holes 13 and 14 thus lie in series with each other, a larger pressure drop may be provided than if merely one throttling is used, since there is a practical delimit for how small the hole 25 30 may be made. Too small holes lead to a risk that the holes are clogged, for instance in connection with the brazing of the plate package.

The holes 13 and 14 disclosed may in an easy manner be 35 manufactured with a desired flow area so that a sufficient throttling and thus a sufficient pressure drop is obtained. The holes

13 - 14 have a diameter, which may vary with the actual application. For instance, the holes 13, 15 may have a diameter, which is less than or equal to 9 mm, preferably less than or equal to 7 mm or more preferably less than or equal to 5 mm.

5 The diameter of the holes 13, 14 is preferably larger than or equal to 1 mm.

In the case that the separate space 11 is delimited by one or several rings 31, 32 as explained above, these rings 31, 32 may 10 include corresponding holes 13, 14 for forming inlet and/or outlet nozzles.

The inlet nozzle and the outlet nozzle may also be formed in another way than through a respective hole extending through the 15 B-plate. For instance, as an alternative, a small passage 15, see Fig. 3, between an adjacent first heat exchanger plate A and a second heat exchanger plate B may be provided in connection with the moulding of the second heat exchanger plate B. In this case, the cooling agent will flow into the separate space 11 via 20 the passage 15 and out of the separate space 11 into the first plate interspace 1 via the hole 14. Also the hole 14 may in an alternative way be designed as a thin passage between the first heat exchanger plate A and the second heat exchanger plate B. In this latter case, the second passages 2 will however receive the 25 cooling agent whereas the first passages 1 receive the fluid cooling the cooling agent. The thin passage 15 may have a cross-sectional diameter or cross-sectional size corresponding to the diameter defined above for the holes 13 and 14.

30 The design of the heat exchanger plates, i.e. the first heat exchanger plate A and the second heat exchanger plate B in the embodiment disclosed, is now to be described more closely in particular with reference to Figs. 4 – 7. Each of the heat exchanger plates A, B extends along a central extension plane 16. 35 The heat exchanger plates A, B are compression-moulded in such a way that they extend from the central extension plane to

an upper plate plane 17 on one side of the central extension plane 16 and to a lower plate plane 18 on the other side of the central extension plane 16.

5 Each of the heat exchanger plates B includes an upper surface area 21, which extends around the first porthole 5. The upper surface area 21 is located at the level of the upper plate plane 17. Each of the second heat exchanger plates B also includes a lower surface area 22, which extends around the first porthole 5
10 and the upper surface area 21. The lower surface area 21 is located at the level of the lower plate plane 18.

Each of the first heat exchanger plates A includes a lower surface area 23, which extends around the first porthole 5. The
15 lower surface area 23 is located at the level of the lower plate plane 18. Each of the first heat exchanger plates A also includes an upper surface area 24, which extends around the first porthole 5 and is located between the first porthole 5 and the lower surface area 23. The upper surface area 24 is located at the
20 level of the upper plate plane 17.

The upper surface area 21 of the second heat exchanger plates B is located partly opposite to the lower surface area 23 of the first heat exchanger plates A for forming the separate space 11 between these surface areas 21 and 23. Furthermore, the lower surface area 22 of the second heat exchanger plates B is partly located opposite to the upper surface area 24 of the first heat exchanger plates A. These two surface areas 22 and 24 will thus partly abut each other in the plate package P in such a way that
25 the separate space 11 is closed to the first inlet channel 6 except via the hole 13 or the thin passage 15.

The hole 13 of the inlet nozzle extends through the lower surface area 22 of the second heat exchanger plates B and is located opposite to the lower surface 23 of the first heat exchanger plates A. The hole 14 of the outlet nozzle extends
35

through the upper surface area 21 of the second heat exchanger plates P and is with regard to the central extension 16 displaced in relation to the second surface area 23 of the first heat exchanger plates A. The position of the hole 14 in relation to the 5 first heat exchanger plate A is indicated in Fig. 6. Since the hole 14 is located at the level of the upper plate plane 17, the hole 14 of the uppermost or outermost second heat exchanger plate B will in an easy manner be closed by the upper sealing plate 3 when the plate package P has been mounted.

10

The separate space 11 will thus be delimited by the upper surface area 21 of the second heat exchanger plates B and the lower surface area 23 of the first heat exchanger plates A. The separate space is delimited to the inlet channels 6 by the lower 15 surface area 22 and the upper surface are 24, which abut each other in the plate package P.

The invention is not limited to the embodiment disclosed but may be varied and modified within the scope of the following 20 claims, which partly has been described above.

25